Surveying and Mapping Education in the United States

Report of the American Congress on Surveying and Mapping National Study on Surveying and Mapping Education

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Table of Contents

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Introduction

For the past two years, a panel representing industry, government and academic professionals in surveying and mapping have met to discuss and study surveying and mapping education in the United States. Significant changes in surveying and mapping sciences brought about by major technological developments and a concomitant demand for new products and services provided the impetus for this study. Such changes are creating a growing demand from industry and government for graduates with new knowledge and skills and a concern about the health and vitality of existing academic programs in surveying and mapping.

Surveying and mapping as a discipline must avoid allegiances to a fixed set of tools and methods. Companies that went out of business manufacturing buggy whips did not realize that they were actually in the vehicle acceleration business. The people producing the last production cycle of buggy whips were undoubtedly proud of their craftsmanship and rich history and tradition, but the world of the automobile made their product obsolete. Many surveying and mapping products risk a similar fate. We must avoid becoming process people --enmeshed in someone else's process -- who identify with tools and techniques that are losing or have lost technical and economic viability.

The surveying and mapping community is in the land information business, not the photogrammetry, surveying, or remote sensing business. Everything done in surveying and mapping has strong connections with the land, its features, topography, topology, social divisions, legal divisions, and its ability to support quality life. Surveying and mapping education must address these issues.

The four principal objectives for this study are:

(a) to review the evolution and current status of surveying and mapping education in the U.S.;

(b) to examine current and emerging requirements for graduates in surveying and mapping disciplines;

(c) to review innovative approaches to surveying and mapping education which have been introduced in the U.S. and elsewhere; and

(d) to develop strategies for further development and enhancement of surveying and mapping education in the U.S.

This report summarizes the results of the study. We begin with a discussion of several trends which we think will influence the surveying and mapping profession and associated academic programs. We continue with a review of data collected in a survey of industry and academia and a discussion of the evolution of the surveying profession during the last several decades, particularly with respect to educational concerns. We then discuss what we see as the implications for education and finish with some general conclusions.

Trends

Changes in contemporary society are increasingly rapid. Frequently, trends run their course and changes occur so quickly that society does recognize their existence, while other trends become deeply rooted and part of the culture. The development of information technology is a trend of the second type and appears to be here to stay. In the book *Megatrends 2000*, John Naisbitt writes, "We have for the first time an economy based on a key resource that is not only renewable, but self generating. Running out of it is not a problem, but drowning in it is."

We examine the effect of defined trends on the surveying and mapping profession in the areas of technology, human resources, and education.

Technology

In the last twenty years, we have seen significant changes in data collection technologies, especially in surveying. The transit and tape has been replaced by the total station, field books have been replaced by data collectors, and pen and ink plotting has been replaced by digital mapping systems. Global Position System (GPS), remote sensing, and photogrammetric technologies are frequently used for primary data collection. Development is occurring at an even faster rate in data analysis, storage, and dissemination. We are entering an era when the concept of an "information highway" is taking hold, and citizens may soon be able to tap into a vast flow of data and information at their workplaces and/or homes.

Human Resources

Changes in the workforce are affecting the surveying and mapping profession. The U.S. Department of Labor reports five major demographic trends in Workforce 2000:

1) "The population and the workforce will grow more slowly that any time since the 1930's.

2) "The average age of the population and the workforce will rise, and the pool of

younger workers entering the workforce will shrink.

3) "More woman will enter the workforce: Almost two-thirds of the new entrants into the workforce between now and the year 2000 will be women.

4) "Minorities will be a larger share of new entrants into the labor force: Non-whites will make up 29 percent of the new entrants into the labor force between now and the year 2000, twice their current share of the workforce.

5) "Immigrants will represent the largest share of the increase in the population and the workforce since the first world war: Even with the new immigration laws, approximately 600,000 legal and illegal immigrants are projected to enter the United States annually throughout the balance of the century.

The Department of Labor concludes that " In combination, these demographic changes will mean that the new workers entering the workforce between now and the year 2000 will be much different from those who people it today. Non-whites, women, and immigrants will make up more than five-sixths of the net additions to the workforce between now and the year 2000, though they make up only about half of it today."

Education

The number of colleges and universities offering surveying and mapping programs has steadily decreased in the past twenty years. Surveying programs have been reduced in size or disappeared at Cornell University, the University of Washington, the University of California, Berkeley, Iowa State University, the University of Illinois, and Virginia Polytechnical Institute. Often when a key individual retires or relocates a program dies. Few schools have developed what might be called an institutionalized surveying program.

Enrollment in surveying programs is not healthy. Of the remaining surveying programs, one school, California State University, Fresno, reports strong undergraduate enrollment figures (130 Students) relative to other surveying programs. Porter McDonnell, in a paper published in the 1990 ACSM-ASPRS Annual Convention Proceedings, noted that eighty six percent of the surveying students polled had some experience in surveying and mapping prior to enrolling. Young students graduating from secondary schools do not consider surveying and mapping as a viable career possibility. Educational requirements for state registration or liscensure have not increased interest or enrollment in surveying and mapping programs.

The demand for surveying and mapping instructors is rising. The demise of surveying programs granting graduate degrees and the instability of enrollments at remaining colleges and universities has produced a secondary trend, a decrease in the number of qualified instructors. Currently there are not enough instructors to fully staff the established college and university surveying programs. States, such as New Mexico, Alaska, and Pennsylvania, which are trying to establish accredited four-year surveying and mapping programs will face an ever increasing struggle to locate qualified faculty. Programs that have been operating for over five years in Colorado, Tennessee, and Arkansas have not yet been able to establish optimum staffing levels.

The demand for knowledge in GIS technology is increasing. In the United States, there are approximately 80,000 government units. If one quarter of these units utilize geographic information system (GIS) technology in the next ten years, we could see as many as 20,000 government units using GIS technology. Given that a typical GIS installation requires six people to setup, install, and maintain, the number of jobs created will be about 120,000. But the real challenge will be educating and training the estimated 1,200,000 people who will be using these systems.

Geography curriculums have exploited GIS technology and are not plagued with the problems surveying and mapping programs are experiencing. The exponential rise in interest in GIS technology has revitalized many geography curriculums but has bypassed the surveying community.

Back-to-basics teaching is gaining momentum over specialized educational experiences. In the last ten years we have witnessed a return to basic educational values; reading, writing, and arithmetic. Many universities are instituting core curriculums for all programs. More recently, however, math and science education, or the lack there of, has been getting much attention in our nations press. As global markets become more competitive, pressure on universities to produce students with stronger math and science knowledge will increase.

Industry Survey

To assess the immediate personnel needs within the profession, approximately two hundred questionaires were sent out to both public and private organizations practicing surveying and mapping. While those selected were by no means a valid statistical sample, panel members attempted to develop a uniform geographic distribution across the country as well as a representation of different sized firms. Results of this survey, based on 80 responses are tabulated below:

Firm Size- number of responses in each size category based on number of employees:

Number of Employees	≤ 20	20-100	≥ 100	Unknown
Number of Responses	29	25	13	13

Current Employment Pattern-Number of Firms With Professional Employees In Each of the Following Categories

Land Surveying	Geodesy	Cartography	Remote Sensing	Photogrammetry	Geography
70	24	40	17	35	35

Anticipated Hiring Pattern-Number of People the Eighty Firms Expect to Hire In Each of the Following Categories During the Next Two Years (1991-92):

Land Surveying	Geodesy	Cartography	Remote Sensing	Photogrammetry	Geography
235	58	105	50	88	42

Skills Required-Number of Firms Indicating Each of the Listed Skills as Important in a New Employee:(values greater than 80 indicate that several firms listed different skills for different categories of employees)

Written Communication	91
Verbal Communication	86
Mathematics - Science	83
Computer Programming	72
Measurement Science	66
Use of Available Computer Software	66
Digital Data Capture	54
Geodesy (GPS)	48
Evidence Evaluation	42
Cartographic Presentation	39
Liberal Studies	15

In addition to the "fill in the blank" questions which are tabulated in Table I, respondents were asked to describe their vision of surveying and mapping education in the U.S. While there were many different answers, a dominant theme appeared to be a perceived shortage of academic programs in the country and an obvious shortage of qualified applicants for the anticipated open positions. There was also a great deal of support for practical "real world" based academic programs with cooperative education or similar experience for the students.

Academic Survey

To evaluate the state of existing academic programs, a questionaire was distributed at the 1990 Surveyors Teachers Conference in Alberta and then mailed to all identified surveying programs within the country. Only four responses were returned. The highlights are summarized below:

University	Cal. State Univ. Fresno	Univ. of Florida	Univ. of Maine	Ohio State Univ.
Department	Civ. and Surv. Engineering	Civil Engineering	Surveying Engineering	Geod. Science and Surveying
# B. S. Students	130	55	65	27
# M. S. Students	10	5	20	67
# Ph. D. Students		2	10	21
# Full Time Faculty	6	4	7	10
Ave. B. S. per yr.	18	- 15	8	8
# research proj. per year	3	6	15	15
Ave. Research $ per year	300K	200K	800K	869K
# funded TA & RA	3	5	20	33

In addition to the data tabulated above, respondents were asked to identify trends which will influence their academic programs for the next five years. The responses are summarized below:

California State University, Fresno: Assuming good to excellent economic conditions, insatiable demand for graduates and increased opportunities for photogrammetry and GIS/LIS graduates.

University of Florida: A recent state law requiring a four-year degree for licensure will increase demand for graduates and therefore bring in more students.

University of Maine: A broadening of the program to focus less on the traditional data collection techniques and more on spatial data management, analysis and use.

Ohio State University: Both the graduate and undergraduate programs will have to resolve the dichotomy between the measurement and information sciences.

Evolution of Surveying

The unique identity of surveying and mapping has been based on (1) land measurement and the (2) representation of measurements through visualization media -- maps. Additional identity has been clearly established for surveyors and mappers in (3) giving expert advice to society on the interpretation of measured and mapped information.

Components of surveying and mapping have evolved with individual sub-identities within the land measurement -- mapping -- interpretation spectrum. ACSM represents three prominent areas: Geodetic surveyors operate almost entirely within the measurement world; cartographers' activities concentrate in the visualization function of mapping; and land surveyors take measurements and make maps but identify most strongly with the interpretation of measured information in a real property sense.

In addition to the three areas formally represented by ACSM, others participate in the land measurement -- mapping -- interpretation profession. Geographers interpret the significance of spatial relationships to society, often with land measurements and maps. Photogrammetry is clearly identified as a land measurement and mapping activity but with little involvement in the interpretation function. Remote sensing is heavily involved in measurement, mapping, and interpretation. Measurements and maps done for engineering and construction of new facilities must be included also.

The diversity of surveying technique and application has caused sub-identities and specialized terminology to develop in sub-disciplines, even to the point that communication across sub-disciplines becomes difficult. These sub-areas may be described as "guilds" that developed rather independently during the last several centuries. In the past, separate professional groups could co-exist with little conversation across borders and therefore little need to develop a common vocabulary, but the computer revolution which ushered in the information age is steadily eroding clear distinctions between groups. Geographic information systems embody a simultaneous application of expertise in all sub-disciplines. It is GIS which has pointed out the inadequacies of our "guild" system and has called for development of a single identity.

There is little doubt that geographic information systems, viewed as a discipline, is within the land measurement -- mapping -- interpretation spectrum, but the advent of GIS has added yet another developing sub-identity along with position titles and job descriptions to match. In recent years, new position titles have developed in common usage within GIS circles, for example: GIS manager, GIS analyst, GIS processor, GIS programmer, digitizer.

New Identity -- Spatial Information

It has become clear that the traditional surveying -- mapping -- interpretation guilds are in the middle of an era based on spatial information. The identity of the past, often based on tools and procedures, causes separate identities that are serving to divide rather than unify. The information age offers a unifying theme -- spatial data and information.

The current transition in surveying and mapping is from passive data collection to proactive involvement in the data rich environment. McLaughlin (1989) has summarized three stages of recent land information management that parallel the evolution of spatial information.

<u>Stage 1 - Learning Stage (circa 1960 - 1975)</u> Stage 1 is distinguished by the development of computerized survey computations, the first automated land records systems, and urban and regional information systems. For the most part, early systems were housed in large organizations and were used primarily for textual data processing although some of the early dot matrix maps that emerged from this stage are still technological wonders.

The educational system response to Stage 1 was the introduction of new courses into old curriculums; computer science emerged as a separate discipline on many campuses, and technical degree requirements were broadened to include social, humanity, and environmental courses.

<u>Stage 2 - Growing Stage (circa 1975 - present)</u> Early computer systems are replaced by commercial packages with increasingly more powerful and sophisticated mapping, computational and analysis capability. The emphasis in the second stage is on the merging of map-based (spatial) records and land records (textual) information. There is also a growing interest in environmental, natural resource, and large system applications. As capabilities and sophistication increases so does the accessibility. A proliferation of new users emerges with each new software release.

The educational responses in stage 2 were major curriculum changes. Surveying engineering and geomatics emerged as potential new disciplines based in new curricula.

<u>Stage 3 - New Solutions</u> Increasingly the focus is on integrated database, distributed networks, public access, and broad based solutions. While the details of stage 3 are not yet apparent, the trends are clear. These trends are:

(a) away from merely developing spatial information processing tools,
(b) into a data rich environment, and
(c) beyond tools and data as we focus on the use of information to more effectively solve problems.

The trends of the educational response are also emerging. The National Geographic Society's and National Science Foundation's efforts are focusing on bringing geography back into the early grades. Surveying and mapping programs are adding courses and redesigning curricula. Introductory surveying courses are being changed to measurement and spatial data collection courses. Map design and production courses are being changed to spatial data analysis and display. Land surveying programs are becoming surveying engineering or land information management programs. Cartography and mapping programs are evolving into statistical and spatial data management, interpretation, and visual display. However, many of these changes are merely patchwork adaptations of former product and tool-based education programs. Re-tooling courses and programs, which are rooted in the past, temporarily fills society's immediate needs but does not respond to the long term changes in the professions.

At the 13th North American Surveying and Mapping Teachers' Conference at Calgary, Ivan Mueller recognized that we are now at a cross-road. On one hand, academic programs could continue teaching the highly technical details of our tools and methods, i.e. surveying, geodesy, photogrammetry, and remote sensing, to a relatively small potential student base, or schools could move toward concentrating on the end-user applications of GIS. The number of students available for this second approach appears to be quite large. Mueller compared the "old scheme" with a proposed "new scheme". The traditional method identified three stages:

(1) data capture (geodesy, photogrammetry, surveying),
(2) data processing (adjustments), and
(3) map (cartography).

Under the new approach the traditional three steps are expanded to five:

(1) data capture,
(2) data processing, data manipulation -- GIS 1,
(3) information storage,
(4) land information management -- GIS 2, and
(5) user applications.

This second approach recognizes two distinct sides to GIS. The first deals with building data where source primary measurements are adjusted or rectified to an overall coordinate system so that the data will overlay. These tasks include data integration and are best performed by traditional measurement and mapping specialists. The second phase of GIS concentrates on the use of an established data base. The information must be managed and manipulated to be suitable for an end-user application.

SIMA -- Spatial Information Mapping and Analysis

A challenging task is finding a single name that embraces all facets of the single discipline composed of our various guilds. We could string all the names together, or invent new words. In Canada, Laval University uses a new term, géomatique, as a unifying discipline name. Others are proposing names such as mapping science, surveying engineering, geo-engineering, geo-information, geo-informatics, and geometronics. Literature abounds with a variety of other names, some involving more traditional wording based on our historical guilds: surveying, geography, cartography, etc.

A strong case can be made for the word *mapping* as one that is currently shared across subdiscipline boundaries without much consternation. The term *spatial* is also rather generic, and does not appear directly in any professional title. Another term *analysis* is often used to depict the act of interpreting the significance of discovered facts and is also generic. The term *information* is also generic and has obvious identity ties to the information age. A reasonable combination of these four may be: *Spatial Information Mapping and Analysis, SIMA*. The precise combination of terms is not important as long as the entire body of knowledge is covered using language that is comfortable to all. For the current discussion, SIMA appears to meet those criteria.

The single person representing this new view of a combined professional may wear three well defined hats:

(1) spatial information developer,
(2) spatial information system specialist, and
(3) spatial information analyst.

A spatial information developer uses measurement and mapping techniques to develop primary information: i.e. field surveying, photogrammetry, remote sensing. The developer also analyzes raw measurements, adjusts them, and produces lists, files, or maps along with attributes for identification of measured items. The identification function is also the responsibility of the developer while the judgment of the survey crew member, photogrammetrist, photo interpreter, or image processor is relied upon for to identity attribute features.

A spatial information specialist handles data and is the integrator, keeper, manipulator, and manager of spatial information. Two systems for spatial information management can be identified: (1) manual, and (2) digital. Even though the specialist will be mainly identified with GIS and digital systems, the nomenclature will work equally well with more traditional graphical (analog) information systems. This person uses highly technical skills and relies on various sources of data from records of a developer as input to a spatial information system that has the capability to: (1) model real world phenomena in digital or graphical form, (2) integrate data from different sources into the data models, (3) store data, (4) retrieve and display data in numerous combinations for a stated purpose, (5) manipulate data, and (6) transmit data.

An analyst, as a professional service, identifies needs and interprets the meaning of developed data for some useful purpose in society. The spatial information analyst is the professional identity wherein needs of the public (clients) are identified and pertinent spatial information is developed, entered into a system, and then extracted in such a form as to be applicable to the analysis required. Independent judgment is applied throughout the process to ensure that the analysis results consisting of opinions and conclusions conveyed to the public (client) are correct. The analyst must be involved with all development and system activities which guide data flow toward the final result of opinions, recommendations, and action.

Implications for Education

In the course of this study, a number of issues and trends with implications for education have been identified and discussed. The following is a review of what we think are the most important of these issues:

Back to Basics

The nearly static surveying and mapping technology of the previous century has been revolutionized and the tools and techniques learned today may have a brief half life. However, fundamental principles of math, physical and social science, land studies, and law which support the majority of our methods and services change rather slowly.

In response to the rate of change in technology and society in general, many universities and professions are increasing the required components of general education in communication, social science,and humanities at the expense of applied technical subjects. Well-rounded and educated graduates will successfully adapt to changing work environments and applications.

<u>Implications for Education:</u> Surveying and mapping education should concentrate on fundamentals that will be useful throughout a forty-year career such as writing, speaking, mathematics, science, geography, geodesy, cartography, theory of observations, and computer science. Highly applied subjects such as detailed studies of existing surveying/mapping equipment and operations have a short life span and should be deemphasized. Students should be encouraged or required to develop a practical background through cooperative educational experiences with industry and government. Technical and community colleges offering two-year associate degrees in surveying technology should be should be encouraged to meet the immediate demand for trained

surveying personnel.

Professional Practice

The scope of practice has narrowed in recent years for the surveying and mapping profession. In many cases, professional surveyors and mappers do not provide a professional service directly to society. Instead, results of their work are passed on to other professions for final interpretation, analysis, and presentation to the public. For example, design data surveys and topographic maps are given to engineers or architects. Environmental maps are given to botanists for final analysis. Geographic data is passed to economists who choose the next location for a retail outlet.

Professional recognition and the resulting rewards are reserved for the provider of end-of-the-line services to the public. Practices of surveyors and mappers should be closely inspected to find areas where the profession may have top-to-bottom involvement with the bottom being problem identification and the top being solution recommendations and implementation. Data collection should be viewed as a means to an end as opposed to a starting and stopping point in itself.

The technology of spatial information gathering has increased the profession's potential for expansion of application oriented services. For example, property appraising is based on massive volumes of data, some of which is collected by traditional surveying and mapping techniques. Once required data is gathered, the professional service of determining land values does not require a great extension of knowledge. In many cases the data, such as comparative sales, speaks for itself. Instead of viewing the traditional boundary surveying service as a fact gathering process for others to interpret, the surveyor may easily provide quasi-legal interpretations and lead property owners to solutions of identified problems within the legal framework. In the area of land development consulting, the survey and mapping professional can assume the role of prime consultant for a proposed activity and provide the final service. Subconsultancies for other specialties of design and analysis as required by law and logic can be arranged by the prime consultant.

<u>Implications for Education:</u> Educational institutions must work closely with professional groups to identify areas where analysis of spatial data may represent attractive professional service opportunities. Curricula should be carefully designed to provide:

(a) a broad general education which gives basic understanding of the world, its' institutions, and its' cultures (communications, literature, humanities, social sciences, basic sciences).

(b) a comprehensive education in the technology of spatial information: data gathering technology (field surveys, photogrammetry, remote sensing) and data management technology (GIS#1).

(c) basic exposure to many areas where spatial information may have applications: law, real estate, environmental studies, sciences, economics, engineering, geography, anthropology, forestry.

(d) application course work where societal problems are identified and spatial information is applied toward a solution: environmental assessment, land development planning, land ownership and administration, economic planning of operations and facilities, and physical planning of facilities. All these subjects should be taught from a spatial information orientation (GIS#2).

Graduate Program as Entry Level

Surveying and mapping educators have tried for many years to unlock the secret of developing vital undergraduate programs. Many schools have tried and failed, and others are continuing with little signs of robustness. At schools that have both graduate and undergraduate programs, the graduate component is easier to develop and maintain than the undergraduate.

Undergraduate surveying and mapping programs in the U.S. offer many career opportunities for graduates but have continuing difficulty in finding a consistent influx of students. Graduate salaries are good, exceeding other established disciplines and career development is good for graduates. The profession and industry are eagerly embracing the future generation of leaders. As a result, graduates move from technical to professional, ownership, and managerial positions readily. But even then, student recruitment is a continuing problem. Parents often tend to discourage their children from majoring in surveying and mapping because of the negative image of the field. Many practicing professionals have a low opinion of their field and discourage potential students. Even state legislation that requires a four-year degree in surveying may not be sufficient to overcome the negative public and professional image of the field. Several states with four year degree requirement laws in place still have trouble filling undergraduate degree programs. In fact, if the four-year degree requirement for registration as a land surveyor becomes common, the long-term effect may be the elimination of the land surveying profession.

On the other hand, graduate surveying and mapping programs tend to be healthy and growing. Students enter from a wide variety of undergraduate backgrounds such as geography, forestry, engineering, and sciences. Many of these academic areas have over-produced graduates so that good career opportunities are not available. For these students, geographic information science is viewed as a highly attractive method of analysis for their native specialty and a potential avenue of employment.

Implications for Education: Future development efforts in surveying and mapping education may be more profitably concentrated on graduate education at the expense of undergraduate programs.

The flow of students with non-surveying undergraduate degrees into a surveying and mapping graduate program can provide a steady stream of talented human resources for the future profession. Redirecting graduate students would be much easier than finding potential high school students, nurturing them past all the negative recommendations, guiding them past all the early academic and personal pitfalls, and finally giving them a vital technical and professional message in the last year of their undergraduate program.

Professional registration rules could be revised to give the master's degree graduate an equal or advanced standing relative to licensure. In return, advanced programs would need to provide a smaller core of courses in traditional surveying and mapping to prepare for the registration process.

Campus Home

Surveying and mapping must identify a range of campus homes for program development. Universities are divided along academic and professional lines. Surveying and mapping, which formerly was taught extensively in engineering, is now being viewed as a distinct discipline closely allied with engineering in its history and some areas of application. The majority of programs developed since 1970 have grown in colleges of engineering. Some of these have come and gone, unable to survive the student recruitment problem.

The spatial information and analysis identity, with a focus on land issues, has brought the surveying and mapping discipline much closer to its ancestral home -- geography. Some have identified surveyors and mappers as "micro-geographers", or as"practical geographers". As a result, geography, as an academic discipline, which already exists on most campuses in the U.S., may be a suitable department for program development.

Geography is rich in end-user applications of spatial information but has generally been limited to issues and data of "macro" scale and application. Combining the micro and practical aspects of issues customarily contained in surveying and mapping with geography's macro view would provide a broad study of land issues with pertinent applications of spatial information.

<u>Implications for Education:</u> Geography should be viewed as a suitable campus location for surveying and mapping program development. Interdisciplinary efforts between engineering and geography should be encouraged. National accreditation guidelines should be expanded to accredit surveying and mapping programs regardless of campus locations.

Problem Identification vs. Solution

Surveying and mapping education has focused in the past on the solution of identified problems. Future surveying and mapping practitioners need to be adept at problem identification as well as solution.

Implications for Education: Future graduates in surveying and mapping should be aware of the important societal issues that are related to spatial information. For example, environmental courses should be studied so that future practitioners may use spatial information to identify as well as solve problems. Legal principles of land use, planning, and real estate will lead to an understanding of land tenure issues. In order to participate in the solution of societal problems today, the surveyor must be involved in identification of the problem. Many technical graduates today are viewed by employers and society as "hired technical guns" who perform specific tasks without involvement in the broader issues of what is being done and why. Future surveying and mapping graduates, with a broad education, should be able to move from technical specialist roles to participants in the great debates of society. To accomplish this, academic surveying programs should require courses from many other disciplines. These will provide the broadening and issue-oriented background needed for future practice.

Within a surveying and mapping program, professional level courses should be more "open-form" where a large range of scientific, societal, legal, and economic issues are debated. "Closed-form" problems leading to a single and correct answer should be relegated to a small number of courses where tools and techniques for data capture are taught.

Networking Hardware and Human Resources

Our accelerated rate of change has made it increasingly difficult for schools to maintain up-to-date laboratories, equipment, and specialty faculty. It may not be a wise use of limited academic funds to buy the latest models of equipment and software.

It is becoming difficult to maintain a faculty to teach courses in the latest tools and techniques. Each new hardware and software item requires a significant learning curve that a faculty member must go through. The life span of this knowledge may be short and the time investment in many cases must be questioned. Industry and government must maintain near state-of-the-art tools and expertise as a normal consequence of their activity.

Implications for Education: Surveying and mapping programs need to find ways of networking with industry and government to supply needed current and detailed applications for the students. In return, the profession needs to create positive programs of assistance for schools to provide exposure to the newest methods.

For example, internships or co-operative education, required as a part of a degree program, expose students to many detailed hands-on applications that can't be taught in school. Equipment suppliers and manufacturers may place equipment in schools through grants or loan. Items to teach field operations may be leased or rented for use in school during a time period each year. Data sets from industry may be shared with schools for reduction and analysis.

Specialty instruction can be provided by government-industry-academic exchange programs whereby faculty are placed in industry or government in exchange for a practitioner coming to the university for a short period.

Supply of Graduates

The brief employment questionnaire of this study shows approximately 500 people are to be soon hired in surveying and mapping disciplines by only 70 identified firms or organizations. At best, there will be 50 baccalaureate surveying and mapping graduates per year in all programs in the U.S. combined. That represents a nearly 10 to 1 ratio of jobs to graduates.

Implications for Education: The majority of employers are hiring those without degrees or with degrees in other disciplines and giving the necessary on-the-job training to redirect the person toward the required work. This practice will continue into the foreseeable future, as there is no possibility of an adequate number of specially educated graduates.

Schools need to continue placing their surveying and mapping graduates in a wide variety of employment situations in industry and government. Since these graduates have the proper education background, they will naturally move up in organizations and their educational background will be recognized. Those who have entered the profession from another undergraduate program will be good potential graduate students.

Conclusion

What does all this mean for the academic community? The notion of identifying a new umbrella discipline, SIMA, is an attempt to break out of the confines of the old tool and procedure oriented guilds and focus on spatial information and a profession suited for the "data rich environment" of the information age. It is an attempt to create a professional avenue which will be attractive to our bright young students who are making career choices. We must make the link between the opportunities our profession can offer and the real challenges our society faces in dealing with many global problems. Nigel Calder in his keynote address for GIS/LIS '91 described our profession as "---privileged craftsman at the start of a great adventure of the human spirit ----

helping to fashion the ships for a rediscovery of the Earth and its peoples". Calder sees the professional goal as gathering the "--- knowledge needed to abolish poverty in the world without harming the Earth".

This does not simply mean that we must do a better public relations job or that superficial changes in existing academic programs will suffice. Much has been made of the fact that Laval University came up with a new name for its' program, Géomatique, and radically increased the level of student and research activity in their department. The change at Laval was not only a new name, but a new idea focused on the collection, processing, analysis, management, and application of geo or earth related information.

Appropriate course and curricular responses must be developed and refined at universities interested in taking part in this profession. These will depend on the skills and abilities of the faculty and staff and on a vision of the appropriate mix of measurement and information studies. That mix will vary from one program to another. Almost twenty years ago Willis Roberts, then director of the Maritime Provinces Land Registration and Information Service (LRIS), posed the question, "Would surveyors lead the the procession into the information age, or be sitting along the side of the parade route?" The question remains to be answered. We hope that this paper will provoke constructive change.

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